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DIABETIC FOOT CARE IN SWEDEN

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Diabetic foot care in Sweden.

THESIS FOR LICENTIATE DEGREE

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ABSTRACT

Diabetes mellitus (DM) is a growing global disorder associated with several complications that include micro- and macrovascular disturbances. Conditions affecting the foot make up one of the major complications of the disease. The overall aim of this thesis was to investigate how developed the diabetic foot care is in Sweden, with the ultimate goal being to identify areas needing improvement.

This thesis is based on two papers:

In **Paper I,** a national inventory was made of a caregiver's organization for diagnosis and treatment of diabetic osteoarthropathy, using a questionnaire addressed to all Swedish hospitals with an emergency department for orthopedic patients. There was a 95% response rate. Three respondents reported never having had any contact with patients with diabetic osteoarthropathy, resulting in an analysis of 57 questionnaires. Most of the respondents (79%) specified an absence of established procedures for managing patients with osteoarthropathy. The most common diagnostic method was clinical diagnosis and conventional plain radiography (95%). MRI or scintigraphy was used by 19% and 10.5% of the respondents, respectively. As a treatment method, 84% used a total contact cast, and 38% orthoses. Two clinics indicated a treatment duration of less than 3 months, thirty clinics (53%) a treatment duration of 3-6 months, and sixteen clinics (28%) a duration of 6-12 months. Only four clinics indicated duration longer than 12 months, while two clinics did not provide any treatment. We noticed a lack of adequate guidelines for the optimal management of diabetes osteoarthropathy.

In **Paper II,** the objective was by a questionnaire to investigate at a national level the organization of multidisciplinary team (MDT) care of patients with diabetes mellitus (DM) and foot complications in all Swedish hospitals, and to what extent they are in line with the Stockholm Consensus Statement from an 1998 assembled expert panel on how to organize treatment and prevention of foot lesions in patients with DM.
The response rate was 92 %. Eighty-four percent of the responding hospitals have a foot team. Most of the teams have *access* to an internal medicine specialist, chiropodist and orthotist. Fewer teams have reported access to an orthopaedic surgeon and infectious disease specialist, and only half to a vascular surgeon. In the joint MDT evaluations of *outpatients,* the majority report regular input of an internal medicine specialist,

podiatrist and orthotist. Approximately 50 % report presence of an infectious disease specialist and orthopaedic surgeon, but only a few of a vascular surgeon. When evaluating *hospitalized* patients there is a reduction in attendance of all specialists. There is low registration of amputation rate and healed foot ulcers. The existence of adequate guidelines could not be confirmed.

Conclusion: The inventory of the management of patient with DM and osteoarthropathy indicates a national need for an improvement in knowledge as well as guidance regarding the early diagnosis and optimal treatment of this condition. Regarding the recommendations in the *Stockholm Consensus Statement,* they are mostly adopted among large and medium-sized hospitals in contrast to small, which could reflect an unequal health care at a national level. Vascular surgeons seldom attend MDT evaluations, and there is a low regular input of infectious disease specialists oriented toward orthopedic infections. There is a remarkable decrease in attendance of all specialists in MDT evaluations of hospitalized patients. We find no support for the ability of hospitals to evaluate their work by potential quality control markers. Our study indicates that national surveys can be valuable in evaluating healthcare organization and management of patient with DM and foot complication.

LIST OF PUBLICATIONS

The two papers included in this study are listed below:

I **Diabetic osteoarthropathy care in Sweden- need for improvement: a national inventory.**

Wennberg L, Lundgren P, Axelsson R, Aspelin P, Gerok-Andersson K, Åkerlund B. *J Clin Transl Endocrinol 2017;9:32-37*

II **Multidisciplinary diabetic foot care in Sweden- a national survey**

Wennberg L, Widgren S, Axelsson R, Gerok-Andersson K, Åkerlund B. Submitted

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LIST OF ABBREVIATIONS

AAOS	American Academy of Orthopaedic Surgeons
CT	Computed Tomography
DFCK	Diabetic Foot Center Karolinska
DM	Diabetes Mellitus
FDG	Fluorodeoxyglucose
HBOT	Hyperbaric Oxygen Therapy
LEA	Lower Extremity Amputation
MDT	Multidisciplinary Team
MRI	Magnetic Resonance Imaging
PAD	Peripheral Artery Disease
PTA	Percutaneous Transluminal Angioplasty
PET	Positron Emission Tomography
RANK	Receptor Activator of Nuclear factor- Kappa B
RANKL	Receptor Activator of Nuclear factor- Kappa B Ligand
SPECT	Single- Photon Emission Computed Tomography
TCC	Total Contact Cast
Tc-MDP	Technetium-99m Methylene Diphosphonate

1 INTRODUCTION

Diabetes mellitus (DM) is one of the most common metabolic disorders in the world, having had a substantial increase during the past few decades and with an estimated prevalence among adults of 8.4% in 2017 that is predicted to rise to 9.9% in 2045 [1]. DM is often accompanied by a broad spectrum of complications, e.g., in such cardiovascular diseases as angina pectoris, myocardial infarction, peripheral artery disease (PAD), and stroke, but also retinopathy and diabetic foot disease [2]. An important factor for patients with DM being able to better control the disease is physical activity, e.g., walking [3]. Physical activity has been found to improve both psychological and physiologic conditions. In order to exercise and walk, it is important for DM patients to have healthy and usable feet. Walking and staying mobile help to improve glucose levels to prevent and better manage type-2 DM [4].

2 BACKGROUND

DM is a metabolic disorder characterized by hyperglycemia that is caused by a defect in insulin secretion, resulting in damage, dysfunction and failure to many organs. DM can be divided into two types: type-1 DM is caused by a deficiency of insulin secretion, and type-2 DM is the result of resistance to insulin and an insufficient compensatory insulin secretion response to glucose [5].

DM is a global challenge for healthcare due to a growing diabetic population and the multiple and long-term complications of the disease that can affect the human body. One of these long-term complications is peripheral sensory neuropathy, which carries the risk of foot complications such as foot lesions and osteoarthropathy [6]. When referring to the variety of pathologic conditions that can affect the feet in patients with DM, the global term “diabetic foot” is used [7].

2.1 DIABETIC FOOT LESIONS

The lifetime risk for a person with DM to develop a diabetic foot lesion could be as high as 25% [8]. The development of foot lesions, particularly ulcers, is associated with a major burden to the patient. Furthermore, the healing of ulcers is related to high costs for society and even higher costs if the ulcer ends in amputation [9–11]. Diabetic foot ulcers are also associated with an increased risk of death independent of other complications [11–13]. A study from the United Kingdom reported that for patients who developed diabetic foot ulcers, 5% died within a year of their first visit to the hospital, and 42.2 % died within five years [12].

Several factors ultimately lead to skin breakdown and development of foot ulcers in patients with DM. These include peripheral neuropathy, vascular diseases affecting the arterial circulation, repetitive biomechanical stress and external trauma [7,14]. Additionally these ulcers are often complicated by infection [15]. Data from the Eurodiale study [16] of 14 European hospitals in ten countries showed that infections were diagnosed in 58% of the patients presenting new foot ulcers. Deep infection tends to be more rapidly progressive in patients with diabetes, with an associated increased risk of lower extremity amputation (LEA) and mortality [17,18].

One of the most important causes of diabetic foot lesions is peripheral neuropathy, which affects motor, sensory as well as autonomic nerve functions [19]. Motor nerve involvement is associated with loss of neural supply to the muscles, which causes limited joint mobility and increased plantar pressure, inducing callus formation [14,20]. The damage to sensory nerves results in a loss of protective sensation, permitting patients with neuropathy to continue walking despite the presence of foot ulcers [20].

Sudomotor dysfunction is a common feature of autonomic neuropathy that involves loss of sweat and oil gland functions. The skin becomes dry and fissured, and susceptible to bacterial invasion [18,21]. Autonomic dysfunction also reduces normal vasoconstriction of the vessels and results in increased intraluminal blood flow and pressure. The combination of high flow and reduced wall motion encourages the formation of plaque in the vessels [22].

As mentioned earlier, PAD is another essential factor in the development of diabetic foot ulcers, due to an inadequate arterial blood flow to the foot [7]. The Eurodiale study reported that PAD was present in around half of the patients diagnosed with new foot ulcers [16].

The cornerstones for treating diabetic foot ulcers are *revascularization, surgical debridement, antibiotic treatment, offloading* and *adequate wound dressings.* Revascularization by percutaneous transluminal angioplasty (PTA) or by-pass surgery is crucial for patients with PAD in order to accomplish a good perfusion of the tissue and limb salvage [23,24]. Surgical debridement is performed to remove necrotic tissue, as well as surrounding calluses, and stimulates the release of growth factors that lead to more progressive wound healing. Debridement also reduces plantar pressure at callus areas and, by acting on the biofilm situation created by the bacteria in the wound, plays an important role in infection control [25–27]. Furthermore, an optimal antibiotic treatment is also needed for managing superficial and deep infections [28,29]. Pressure relief of ulcers via offloading may be necessary to reduce the pressure and tension on plantar foot ulcers. This can be achieved using custom-made insoles and individually adjusted footwear [30] or other pressure-relief devices such as a non-removable total contact cast to manage plantar neuropathic ulcers [31]. In order to create the ideal milieu for healing, an optimal wound dressing is essential [32]. Other methods have been suggested as being useful as add-on therapies to gold-standard wound care, e.g.,

hyperbaric oxygen therapy (HBOT). However, more research is necessary to establish adequate evidence of the efficacy and cost-effectiveness of these new methods [33].

The substantial health economic consequences of patients with diabetic foot lesions includes intervention to prevent and heal foot ulcers, and, in cases of amputation, costs also associated with the care necessary for post-amputation disability. Studies have also shown that the duration of wound healing and repeated surgery as well as healing with amputation are important cost driving factors due to multiple and extended hospitalization in patients with DM and foot infections [34–37].

2.2 DIABETIC OSTEOARTHROPATHY

Diabetic osteoarthropathy also known as Charcot foot is a condition affecting the bones, joints, and soft tissues of the foot and ankle [38]. The condition may occur as a complication of neurosyphilis, syringomyelia, leprosy, poliomyelitis, alcohol abuse, traumatic injury, heavy metal poisoning, multiple sclerosis, congenital neuropathy and rheumatoid arthritis [39]. However, diabetes has, since it was first associated with osteoarthropathy, become the most common etiology for this condition [38] and is the focus of paper I of this thesis.

Osteoarthropathy of the small bones in the foot and ankle due to DM is a condition that was described by Jean-Marie Charcot in patients with tabes dorsalis in 1883 [40]. Herbert William Page preceded Charcot by two years when he presented a case at the 7th International Medical Congress in London in 1881, something that was in fact acknowledged by Charcot and Charles Féré in their 1883 article [41]. The condition has thus been known for a relatively long period of time. Nevertheless, the arsenal of diagnostic tools and treatment options has remained meager. In fact, up until recently, the base of knowledge had not expanded a great deal beyond the publication of Charcot´s article [42], although the surgical techniques for reconstruction of the foot have improved with the surgical developments of the 20th century.

2.2.1 Pathophysiology of diabetic osteoarthropathy

Diabetic osteoarthropathy is, in the acute phase, presented as an inflammatory warm, swollen, and erythematous foot and ankle. The skin temperature of the affected foot measures 2-6°C higher than the contralateral foot, and pain may or may not be present, depending on the magnitude of the nerve damage [7,43,44]. The acute phase can rapidly progress to a chronic stage, if not diagnosed early and properly treated, resulting in irreversible foot deformities, e.g., plantar subluxation of the hindfoot, or so-called rocker-bottom deformity [38,45].

There are different theories concerning the origin of diabetic osteoarthropathy: namely, a neurotraumatic and a neurovascular theory. The neurotraumatic theory highlights that the lack of sensation allows for micro-trauma that leads to the progressive destruction of bone and joints. The neurovascular theory suggests that a neutrally initiated vascular reflex leads to the activation of osteoclasts, and thus bone resorption and fragility of the bone [41]. However, neither of these theories can fully explain the development of diabetic osteoarthropathy. A more recent theory [42,46] states that in patients with acute diabetic osteoarthropathy, the foot is characterized by an unregulated, local inflammatory response to a minor trauma. As a result of the local inflammation, proinflammatory cytokines are increased and go beyond control, leading to excessive amounts of the protein receptor activator of the nuclear factor kappa B ligand (RANKL). RANKL binds to the receptor RANK on the osteoclasts and stimulates their maturation and activity, resulting in bone loss [46]. A recent report shows an effect of RANKL antibody treatment on diabetes osteoarthropathy [47].

Neuropathy is a well-established factor underlying diabetic osteoarthropathy, leading to nerve damage affecting sensation to hot and cold stimuli [48] and abnormal pain sensations. As described earlier, diabetic osteoarthropathy often begins with an unperceived injury and is then worsened by continuing painless weight bearing. Due to limited joint mobility, increased plantar pressures and abnormal walking [49], the patients feet are frequently traumatized, which leads to multiple bone fractures.

The pathway of foot fractures in general can be different in patients with type-1 and type-2 diabetes. In patients with type 1 DM, fractures are frequently related to

peripheral osteopenia and reduced bone mineral density [50]. On the contrary, in type 2 DM an increased bone mineral density has been observed [51], but bone strength may actually be lower due to microarchitectural bone defects leading to bone fragility [52]. Diabetic fractures are therefore mainly associated with the alternation of weight bearing and the load of the foot.

2.2.2 Diagnosis

Clinical and radiological diagnoses of acute diabetic osteoarthropathy are challenging due to its clinical presentation being similar to what is seen in erysipelas and deep venous thrombosis [44]. Also, osteomyelitis could be a differential diagnosis and can co-exist with osteoarthropathy in the same extremity [53]. Follow-up of patient with DM and acute osteoarthropathy based on signs such as skin temperature, pain, swelling, and erythema are useful indicators of the outcome of the disease [54,55] but lack specificity and sensitivity.

Different types of classifications have been used to describe the clinical and radiological changes of diabetic osteoarthropathy The first classification described was the Eichenholtz stages, which correlate to the three physiological stages of healing of a fracture: inflammation, repair and remodeling [56,57]. An additional stage 0 has been added for early diagnosis, where no detectable radiological changes are found and are characterized by inflammatory foot edema [58].The Eichenholtz stages are based on a plain x-ray that is used as an initial modality with standardized dorsoplantar and lateral radiographs that can also be performed with the patient weight-bearing to assess foot alignment and subtle instability [59,60]. An additional pronated oblique position of the foot is often included in the examination to clearly demonstrate the tarsometatarsal and mediotarsal joints [61]. The earliest finding of diabetic osteoarthropathy in a plain x-ray is a widening of joint space and focal demineralization of bone [62]. A plain x-ray can be important for monitoring progression of a developed deformity [44]. However, if a radiological method is to be used, the method must be able to detect the condition in the acute phase before any bone destruction. Other diagnostic imaging modalities, including magnetic resonance imaging (MRI) and nuclear medicine methods, have helped to recognize early signs of inflammation and underlying bone damage before overt bone and joint destruction has occurred [63].

MRI can provide valuable diagnostic information by allowing the early identification of soft tissue edema, bone marrow edema, microfractures, hidden fracture lines or abnormal bone turnover before it can be seen on radiographs [62,64]. Soft tissue inflammatory changes and bone marrow edema is characterized by a decreased signal intensity on T1-weighted and high signal intensity on T2-weighted images [44]. Since the Eichenholtz classification does not cover the whole spectrum of diabetic osteoarthropathy, it has been suggested that they should be abandoned rather than extended, and that MRI should replace plain radiography for diagnosing and monitoring the affected foot [65].

Bone scintigraphy is a common nuclear medicine procedure and can be useful for the evaluation of diabetic osteoarthropathy by revealing an increased uptake along the affected bone and joints [58]. A Technetium-99m labeled methylene diphosphonate (Tc-MDP) is used for imaging, which is commonly performed in three phases. Imaging directly after injection demonstrates the perfusion of the foot [66]. The second phase demonstrates leakage of imaging agents to surrounding soft-tissues/ muscles. After this follows the delayed phase, where the tracer uptake mirrors the rate of bone remodulation. Additionally, a fourth phase can be added after 24 hours by showing a static image that can enhance specificity [44,66]. A disadvantage of scintigraphy is the poor spatial resolution and the lack of anatomical landmarks. The more modern hybrid systems combining a gamma camera with Computed Tomography (SPECT/CT) can overcome this last limitation.

2.2.3 Treatment

The current standard treatment for osteoarthropathy is immobilization with casting therapy. The goal if there is a fracture is to redistribute the plantar pressure to limit bone and joint destruction in order to maintain a plantigrade foot with minimal deformity and also to prevent further foot fractures. If no fracture has yet appeared, the aim of a total contact cast (TCC) is to prevent a fracture [67]. With casting therapy the foot will be offloaded, thereby reducing mechanical forces, edema, inflammation and arrest the development of the osteoarthropathy [68]. When the affected foot is offloaded with a (TCC) [69], the patient has to be checked once every week and the TCC has to be changed frequently [38]. Other casting therapies that are used are removable modalities

such as orthoses and bivalve casts. To reduce mobility a TCC is preferable as compliance with the treatment is thereby enforced [31,70].

Diabetic osteoarthropathy that allows to develop into deformities of the foot are difficult to treat with orthotic devices and can therefore be considered for surgical reconstruction. The indications for surgical reconstructions are instability [71], recurrent ulcers, inability to heal ulcers, and presence of osteomyelitis and pain [72].

2.3 GUIDELINES ON THE PREVENTION AND MANAGEMENT OF THE DIABETIC FOOT

Several initiatives have been made to improve diabetic care at both international and national levels. In 1989, representatives of government health departments and patient organizations from European countries met in Saint Vincent, Italy, under the auspices of the World Health Organization (WHO) and the International Diabetic Federation (IDF). The meeting resulted in the Saint Vincent Declaration [73], which prescribe some fundamental goals for reducing individual and social burdens of diabetes. In the declaration, a five-year target was set that there should be a 50 % reduction of lower-limb amputations for patients with DM. Unfortunately, this has not yet been achieved.

As a follow-up to the Saint Vincent Declaration, an expert panel met in Stockholm in 1998 to create consensus on the prevention and treatment of foot ulcers in patients with DM on a national level [74]. Physicians and nurses, chiropodists, parliamentarians and economists discussed how health care should be organized and how preventive work and treatment should be performed. In the consensus statement, they underlined the need for implementing MDT in the care of patients with DM and foot problems. In 1996 the International Working Group on the Diabetic Foot (IWGDF) was founded [75] to prevent and reduce the unfavorable effects of diabetic foot problems. Based on evidence from high quality studies, the IWGDF continuously update the international consensus guidance on recommendations for daily clinical practice of prevention and management of foot problems [76]. IWGDF further supported the importance of a multidisciplinary approach for treating diabetic foot complications.

2.4 MULTIDISCIPLINARY FOOT TEAM

Major international and Swedish guidelines recommend that patients identified with new diabetic lesions should be referred to a dedicated multidisciplinary team (MDT) [74,77,78].

An MDT is a group of specialists with varied, complementary experiences and knowledge that contribute to achieve specific objectives in a clinical situation [79].

The aim for an MDT is to manage patients according to a diabetic foot care process through rapid and accurate assessment of the condition of the diabetic foot. An important issue for the MDT is to diagnose infection early so that antibiotics and debridement can be started immediately, if needed. The MDT task is also to perform an assessment of ischemia to evaluate the need for early revascularization [80]. Several studies emphasize the importance of an MDT approach that includes preventive strategy, patient and staff education, and multifactorial treatment of complex foot lesions to obtain satisfactory limb salvation [81–83].

According to the Stockholm Consensus Statement [74], different composition of an MDT were recommended at different levels – primary care, local hospitals and large (university) hospitals. The responsibility of the primary care is to prevent the development of diabetic foot lesions and, when necessary, collaboration with a foot team at a local hospital. Such a team preferably consists of an internal disease specialist, surgeon or orthopedic surgeon, and a chiropodist. They represent a medium level of the diabetic foot care assessing foot lesions. Furthermore, some diabetic foot centers are recommended to be established in larger hospitals with expertise consisting of a diabetologist, diabetes specialist nurse, orthopedic surgeon, vascular surgeon, infectious disease specialist, podiatrist, orthotist, radiologist and physical therapists [74].

3 AIMS OF THE THESIS

The overall purpose of the research described in this thesis was to investigate diabetic foot care in Sweden.

Specific aims:

The purpose of paper I was to create a national inventory of orthopedic caregivers' organizations for the diagnosis and treatment of diabetic osteoarthropathy.

The aim of the paper II was to investigate whether the recommendations of the *Stockholm Consensus Statement* regarding the establishment of MDT for the management of DM patients with foot complications are being implemented at hospitals in Sweden. Furthermore, we also intended to briefly analyze if the work could be evaluated by potential quality control markers.

4 MATERIALS AND METHODS

The thesis is based on two parts. Data was collected by structured questionnaires for both parts. Based on the "Swedish Association of Local Authorities and Regions" registry, the questionnaires were distributed via postal mail to all Swedish hospitals with emergency departments.

4.1 PARTICIPANTS

4.1.1 Paper I

The head of the orthopedic clinics at each emergency hospital were contacted to identify the orthopedic surgeon responsible for the care of patients with foot complications. The responsible orthopedic surgeons were then contacted by e-mail with a description of the project's purpose and an announcement that they were going to receive a questionnaire. Since 14 of the hospitals were so-called ''joint orthopedic clinics", with shared organizational structures, 63 units received the questionnaire. Three respondents stated that they had never dealt with patients with diabetic osteoarthropathy, and therefore the analysis was based on responses from 57 clinics.

4.1.2 Paper II

The questionnaire was sent to all 75 Swedish hospitals with emergency departments. Healthcare providers responsible for the diabetic foot care at each hospital were identified and received the encoded questionnaire. Information concerning the number of beds available at each hospital was collected from the hospital's webpage. The hospitals were then arranged in three groups according to the number of beds available: small hospitals < 250 beds; medium-sized hospitals 250-500 beds; and large (university) hospitals > 500 beds. Forty hospitals were classified as small, nineteen as medium-sized and sixteen as large.

4.2. QUESTIONNAIRES

The questionnaires from the two studies were designed in consultation with the co-authors of each study. Furthermore the questionnaire in paper I was sent to experienced orthopaedic surgeons (not included in the study) for comments on the formulation, and the questionnaire in paper II was developed in collaboration between Diabetic Foot Center Karolinska (DFCK) and the Swedish Diabetic Association. The questionnaires were coded, and a summary of the incoming responses was compiled without identifying individual units. No application for ethical approval was needed.

4.2.1 Paper I

The questionnaire was based on eight questions regarding diagnosis and treatment of patients with diabetic osteoarthropathy. We asked how many patients with diabetic osteoarthropathy were seen annually and if there were existing guidelines. If there were current guidelines, the respondents were asked to include them when returning the questionnaire. Furthermore, we asked about methodology used to diagnose diabetic osteoarthropathy, how soon after suspicion of the disorder the patient obtained an appointment time, and what treatment the patient received as well as the duration of treatment. The respondents were also questioned whether they had access to reconstructive foot surgery for foot deformities caused by diabetes osteoarthropathy.

4.2.2 Paper II

The questionnaire consisted of eight questions regarding which hospitals had an MDT and their access to different specialists, as well as these specialists' attendance in the MDT evaluation in outpatient care and for hospitalized patients. Additionally, we asked if they had treatment guidelines, and if the hospitalized patients were in a specialized ward or if their beds were in various wards.

The questionnaire also contained questions regarding quality control markers, such as a local registration of the annual number of amputations on patients with DM as well as a registration of healed ulcers. We also asked if patients received written information for their general practitioner and district nurse when visiting the clinic.

4.3 DATA ANALYSIS

The data were downloaded into Microsoft Excel, and analyzed and computed in terms of frequencies and percentages using the Statistical Package for Social Sciences (SPSS) Windows version 22.0. The received guidelines in study I were assessed using diabetic (Charcot) foot management directives from the American Academy of Orthopaedic Surgeons (AAOS) [84].

4.4 ETHICAL CONSIDERATIONS

No application for ethical approval was done. According to ethical principles [85], all respondents were informed about the overall purpose and features of the project in which they were agreeing to participate. All participation was voluntary. The respondents were also informed that the questionnaires were coded and the responses that were received were compiled without presentation of their individual units. Additionally, data collected for the purposes of this research will not be used for commercial or other non-scientific purposes.

5 RESULTS

5.1 PAPER I

The questionnaires were sent to 63 Swedish hospitals with emergency departments for orthopedic patients. We received responses from 60 hospitals and experienced a 95 % response rate. Three respondents returned the questionnaire with the reply that they did not manage patients with diabetic osteoarthropathy. They did not answer the questions in the questionnaire and are, therefore, not included in the analysis. We asked the remaining 57 hospitals how many patients they estimated handling at the clinic annually (Table 1). Most of the respondent reported managing one to five patients every year.

Table 1. Estimated number of patients with diabetic osteoarthropathy managed annually.

Number of patients	**n=57 (%)**
0	4 (7 %)
1-5	26 (45,6%)
6-10	8 (14 %)
>10	15 (26,3 %)
Do not know	2 (3,5 %)
No answer	2 (3,5 %)

Out of the 57 hospitals included in the analysis, 10 claimed to have established guidelines for managing patients with diabetic osteoarthropathy. However, when asked to bring the guidelines together with the questionnaire, only seven were included. Furthermore, when evaluating the guidelines according to the recommendations by the AAOS [84] only two were assessed as adequate.

Only 2 of the respondents responded that patients with suspected diabetic osteoarthropathy made an appointment at their clinic within 1 day, 26 stated that it took 1-5 days and 18 clinics answered > 5 days. Additionally, 11 respondents did not know. Most of the respondents used several methods to diagnose patient with diabetic osteoarthropathy. Fifty-four clinics stated that they performed a clinical diagnosis followed by plain X-ray (table 2). In addition, 37 clinics complemented the diagnosis with an MRI and/or bone scintigraphy.

Table 2. Methodology used to diagnose diabetic osteoarthropathy

Method for diagnosis	n=57 (%)
Clinical diagnosis	54 (95,5 %)
Skin temperature	31 (54 %)
Plain X-ray	54 (95,5 %)
Bone scintigraphy	6 (11,5 %)
MRI	34 (60 %)
Do not know	1 (1%)

The responses concerning the treatment methods indicated that 47 clinics used a TCC, and 31 clinics stated that a TCC was the only casting treatment they used, 5 used orthoses alone and 1 used only a bivalve cast, which is a removable cast. In combination with a TCC, 26 clinics used different casting treatments, while 3 respondents stated that they did not know. In a few cases, additional options were also specified such as the Don Joy Walker (2%), the Walker from Össur (2%) and PTB Orthosis (2%). Ten of the responding clinics specified having an orthosis option, despite having only listed the total contact cast as a treatment method.

Table 3. Treatment duration for patients with diabetic osteoarthropathy

Treatment duration	n=57 (%)
No treatment	2 (3,5 %)
<3 months	2 (3,5 %)
3-6 months	30 (52,6 %)
6-12 months	16 (28,1 %)
>12 months	4 (7 %)
No answer	3 (5,3 %)

Of the 57 clinics, 34 claimed having access to reconstructive foot surgery for diabetic osteoarthropathy, 11 referred the patient to the nearest university hospital and 9 to the regional hospital. Two clinics reported not knowing, and one referred the patients to other unspecified clinics.

5.2 PAPER II

Out of all 75 Swedish hospitals with emergency departments that received the questionnaire, 69 responded, resulting in a 92 % response rate. As the hospitals have different conditions for MDT work, the responses that were received were grouped and presented according to size: small hospitals, medium-sized hospitals and large hospitals. Out of the questionnaires that were received, 11 claimed to have no access to an MDT (Fig 1). Only the hospitals claiming to have access to an MDT were included in further analysis.

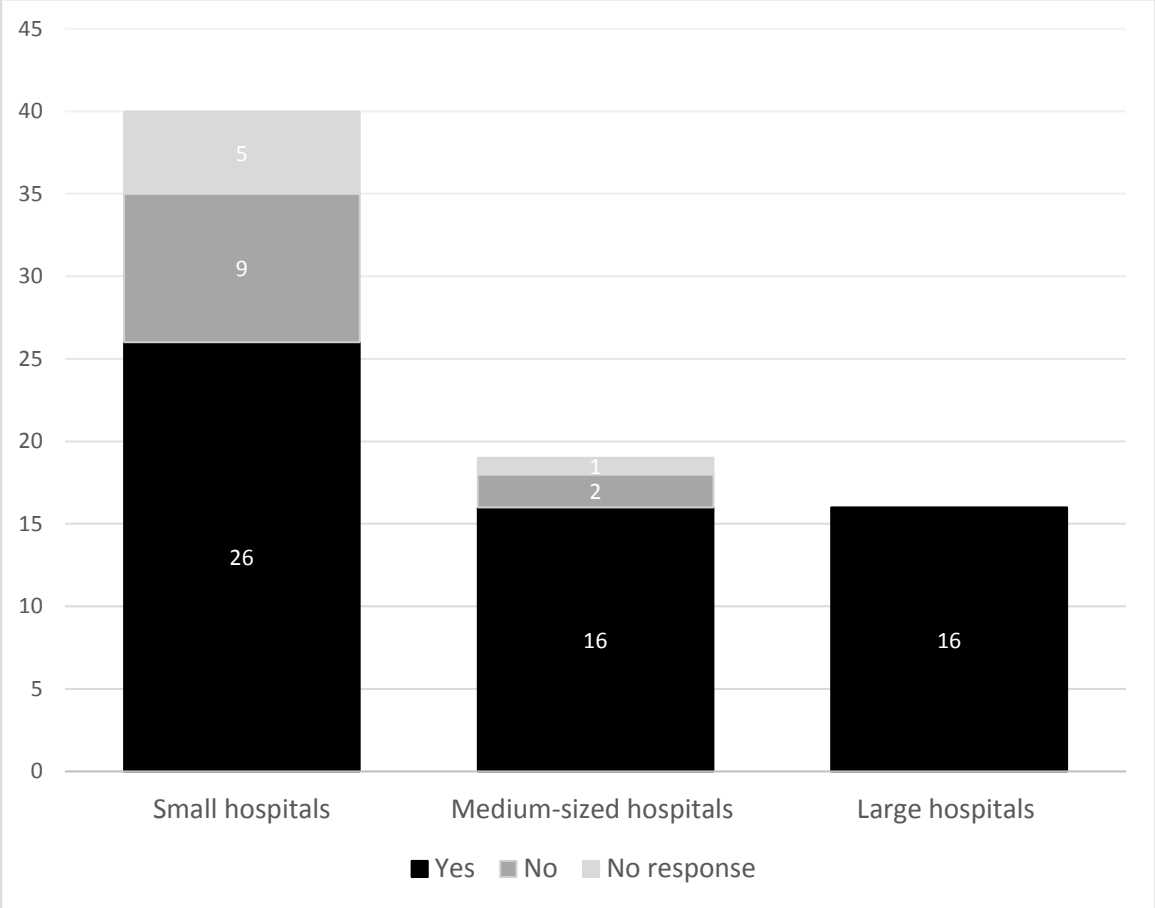

Figure 1. The number of hospitals with access to an MDT, according to size.

Table 4. Specialists the MDT reported having access to.

Specialists	**Small hospitals** n=26 (%)	**Medium-sized hospitals** n=16 (%)	**Large hospitals** n=16 (%)	**Total** n=58 (%)
Specialist in general internal medicine	8 (31 %)	0 (0 %)	1 (6 %)	9 (16 %)
Diabetologist	15 (58 %)	15 (94 %)	15 (94 %)	45 (78 %)
Specialist in orthopaedic surgery	9 (35 %)	3 (19 %)	3 (19 %)	15 (26 %)
Orthopaedic surgeon with experience in foot surgery	8 (31 %)	12 (75 %)	10 (63 %)	30 (52 %)
General infectious disease specialist	9 (35 %)	5 (31 %)	9 (56 %)	23 (40 %)
Infectious disease specialist with experience in orthopedic infections	2 (8 %)	10 (63 %)	3 (19 %)	15 (26 %)
General vascular surgeon	6 (23 %)	2 (13 %)	1 (6 %)	9 (16 %)
Vascular surgeon with experience in extremity surgery	5 (19 %)	8 (50 %)	9 (56 %)	22 (38 %)
Podiatrist	25 (96 %)	16 (100 %)	15 (94 %)	56 (97 %)
Orthotist	23 (89 %)	15 (94 %)	15 (94 %)	53 (91 %)
Diabetes specialist nurse	23 (89 %)	13 (81 %)	8 (50 %)	44 (76 %)

Participation of all specialists decreased in the MDT evaluation of hospitalized patients (Table 6) in comparison to outpatients (Table 5). The main difference was in the participation of the chiropodist and the orthotist, where the attendance decreased by 32 % for the podiatrist and 34% for the orthotist.

Table 5. Specialists attending the MDT evaluation of outpatients

Specialists	**Small hospitals** n =26 (%)	**Medium-sized hospitals** n=16 (%)	**Large hospitals** n=16 (%)	**Total** n=58 (%)
Internal medicine specialist	23 (88 %)	15 (94 %)	14 (88 %)	52 (90 %)
Orthopaedic surgeon	12 (46 %)	13 (81 %)	11 (69 %)	36 (62 %)
Infectious disease specialist	6 (23 %)	14 (88 %)	10 (63 %)	30 (52 %)
Vascular surgeon	5 (19 %)	7 (44 %)	1 (6 %)	13 (22 %)
Podiatrist	24 (92 %)	16 (100 %)	15 (94 %)	55 (95 %)
Orthotist	22 (85 %)	14 (88 %)	15 (94 %)	51 (88 %)

Table 6. Specialists attending the MDT evaluation of *hospitalized* patients.

Specialists	**Small hospitals** n=26 (%)	**Medium-sized hospitals** n=16 (%)	**Large hospitals** n=16 (%)	**Total** n=58 (%)
Internal medicine specialist	19 (73 %)	8 (50 %)	8 (50 %)	35 (60 %)
Orthopaedic surgeon	10 (39 %)	7 (44 %)	11 (69 %)	28 (48 %)
Infectious disease specialist	6 (23 %)	11 (69 %)	7 (44 %)	24 (41 %)
Vascular surgeon	3 (12 %)	4 (25 %)	5 (31 %)	12 (21 %)
Podiatrist	14 (54 %)	5 (31 %)	4 (25 %)	23 (40 %)
Orthotist	9 (35 %)	4 (25 %)	4 (25 %)	17 (29 %)

Sixty percent of the hospitals have a specialized ward (50 %, 69 %, and 69 % respectively according to size) for hospitalization of the patients, and ten percent report having both scattered beds and a specialized ward (4 %, 19 %, and 13 % respectively). Fifty percent of the hospitals with MDT reported having scattered beds (54 %, 50 %, and 44 % respectively).

When the hospitals were asked whether they had established guidelines for managing patients with DM and foot ulcers, 67% claimed they had. Furthermore, 57% stated that the patients received written information ("treatment message") for their general practitioner and primary care nurse when visiting the clinic.

The hospitals were also asked whether there was a local registration of the annual number of amputations and healed foot ulcers as potential quality control markers for

evaluating their work. Of all hospitals included in the analysis, 48 % reported having local registration of the annual number of amputations and 21% for healed foot ulcers (Fig. 2).

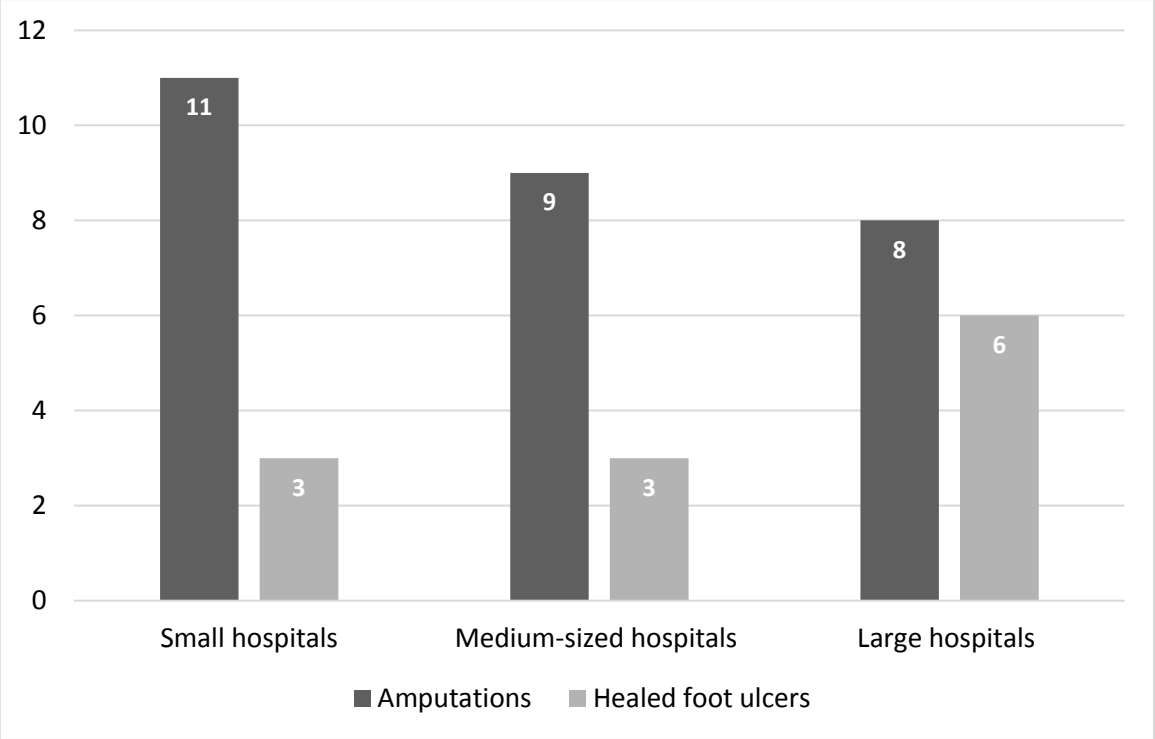

Figure 2. Number of hospitals with local registration of the annual number of amputations and healed ulcers.

6 DISCUSSION

Long-term diabetes-related complications are likely to become more common, due to the increasing prevalence of the disease [1]. In particular, the diabetic foot is associated with reduced health-related quality of life and substantial costs for the society. This is further accentuated if the outcome is amputation, resulting in prolonged hospitalization and need for rehabilitation and home care [86–91].

In accordance with recently reported audits in other countries, especially the United Kingdom, there can be a certain value in national surveys for evaluating the care of patients with DM, allowing an organization to deal with inadequacies in its management [92–97].

6.1 DIABETIC OSTEOARTHROPATHY CARE

In Sweden today, there is no official record concerning the incidence of osteoarthropathy in patients with DM. Neither do we know the consequences of a diabetic osteoarthropathy diagnosis. The incidence of diabetic osteoarthropathy is likely to be underestimated due to failure to recognize the initial clinical manifestation of a hot swollen foot [98,99]. Furthermore, there have been reports of misdiagnosis and delay of treatment [43,100] explained by the patient´s lack of protective sensation. In paper I, we have only arrived at an estimated number of patients with diabetic osteoarthropathy from the respondents. There seem to be a need to investigate this further at the national level. It is likely that some kind of a national registration linked to the Swedish national diabetes register will be necessary to arrive at the real incidence. Previous studies have tried reporting the incidence of diabetic osteoarthropathy. A retrospective study from Denmark [101] followed an average of 4,000 patient over a 10-year period. An annual incidence of diabetic osteoarthropathy of 0.3 % in a population with diabetes was found. Each patient presented a red warm swollen foot with radiological evidence of osteoarthropathy. Another study reported an incidence of 8.5/1,000 per year in Hispanic whites and Mexican Americans diagnosed with diabetes [8]. In this study, osteoarthropathy was defined as a lower extremity fracture or dislocation in the presence of sensory neuropathy with loss of protective sensation. This indicates that diabetic osteoarthropathy should be considered in all patients presenting with neuropathy, edema, erythema, and increased temperature of the foot. If the diabetic

osteoarthropathy of the foot can be recognized without delay, followed by immediate offloading, fractures and incapacitating deformities can be minimized, and devastating morbidity and mortality substantially decreased [102]. In addition, a delayed diagnosis of diabetic osteoarthropathy results in a significantly increased acute health care cost and longer hospitalization time. A recent study showed that a delayed osteoarthropathy diagnosis was associated with a 10.8 % greater inpatient cost and 12.1 % longer hospitalization time [103].

When asking about the methodology that was used to diagnose diabetic osteoarthropathy, 65 % reported further investigation of patients with MRI and/or bone scintigraphy after the clinical examination and the plain X-ray. Studies have shown that MRI and bone scintigraphy can reveal pathological changes that correlate with diabetic osteoarthropathy in patients after the onset of erythema, edema, swelling and increased temperature of the foot when a plain x- ray is considered normal [102]. MRI showed bone marrow edema, and bone scintigraphy with Technetium 99m showed increased isotope uptake, which is, however, nonspecific and cannot differentiate between osteomyelitis and osteoarthropathy. The value of bone scintigraphy is therefore limited to negative results and excluding of bone engagement. Another useful nuclear medicine method in diagnosing inflammatory and infectious entities is positron emission tomography (PET) using the tracer fluorodeoxyglucose (FDG). FDG is a variant of glucose with the same uptake in cells as regular sugar. Since inflammatory cells need more glucose than healthy cells, there is an increased uptake of FDG in inflammatory areas seen on the FDG-PET image [104]. Despite the high sensitivity, there is limited specificity [105].

Computed tomography may be useful in detecting cortical bone destruction and periosteal bone formation, but it cannot differentiate between purulent, granulation tissue, inflammation, or fibrosis [106]. However, CT in combination with positron emission tomography (PET), so-called PET-CT, or single- photon emission (SPECT) CT can correlate anatomical location with areas of uptake contributing to bone marrow evaluation [44,63]. Moreover, studies have indicated that fluorodeoxyglucose (FDG) PET can reliably distinguish diabetic osteoarthropathy from osteomyelitis both in general and with the presence of a foot ulcer [107–109]. These publications are based on a small number of observations, and larger clinical trials are needed to establish the role of FDG-PET/CT in these patients. Furthermore, the low availability of PET/CT

may be a limiting factor in using these hybrid imaging methods. Other diagnostic imaging methods like sonography may visualize abnormalities on the surface of the bone [106].

In paper I, 47 clinics claimed to use TCC even if they also reported using alternative casting treatments, e.g., a bivalve cast or/and orthoses. Whether these casting modalities followed each other during the same treatment period is unclear. In the active stage, the foot affected with osteoarthropathy should be immobilized and offloaded until the inflammation subsides and the fractures heals [67,110], and TCC has been suggested as the current standard therapy [67,111,112]. However, there are controversies associated with the non-removable or removable cast [110]. Previous studies have shown that TCC was the first choice of management in fewer than half the cases [113,114]. Furthermore, strict non-weight-bearing therapy of the affected foot can lead to unfavorable consequences on the contralateral, non-affected foot due to increased mechanical forces. People with TCC-treated diabetic osteoarthropathy also have a risk of falling because of increased instability. Furthermore, immobility has a disadvantage due to loss of muscle tone and bone density [38]. The duration of casting therapy has also been debated. In the study question concerning the treatment duration for patients with osteoarthropathy, we provided the respondents with the options <3 months and 3-6 months, etc. Previous clinical studies indicate no further reduction of bone mineral density of the Charcot foot after three months of casting therapy, although the foot was treated until clinical resolution [42,115]. Additionally, the increased concentration of proinflamatory cytokines TNF-α and interleukin-6 in osteoarthropathy are significantly reduced after three months of casting therapy with no further changes measured at clinical resolution [42]. The clinical resolution was defined as the time lapsing before the temperature difference between the feet was < 2°C at two consecutive monthly visits.

Diabetic osteoarthropathy that develops with deformities are challenging to treat surgically as these operations are associated with a high rate of complications [116]. There is, therefore, emphasis on the need for orthopaedic foot surgeons with vast experience in various surgical approaches, because the quality of the soft tissue is decisive as to which approach can be employed [72].

6.2 MDT CARE

In the inventory of MDT management of patients with DM and foot complications, most of the respondents claimed having some kind of organized MDT for diabetic foot care. However, due to the complexity and multifactorial manifestation of the diabetic foot, the composition of the team can be of utmost importance to the outcome. In the case of successful organized MDT care, there can be a reduction of LEA, length of hospitalization and death rates [117,118]. A study from the university hospital in Lund, Sweden reported that two-thirds of patient with diabetic foot ulcers healed without amputation when treated in an MDT, even if the time to heal the ulcers was long [119]. The MDT consisted of a diabetologist, an orthopaedic surgeon, a nurse specializing in diabetes, an orthotist and a chiropodist, and the team also cooperated and had access to vascular surgeons and specialists in infectious diseases. Moreover, an MDT approach has shown to be successful in other areas such as the rehabilitation of patients with chronic pain, as it leads to better coping, lower depression scores and higher social activity, which contributes to lower sick leave [120,121]. Furthermore, MDT in cancer care has also reported multiple benefits such as more accurate treatment recommendations and adherence to clinical guidelines, improved quality of life for patients [122–124] and significantly shorter intervals between diagnosis and treatment [125]. However, the need for clarified roles for the different health professions included in the MDT has been highlighted due to the overlapping areas of expertise [122,126].

6.3 MEMBERS OF THE MDT

In about half of the teams, infectious disease specialists (52 %) attended the MDT joint evaluation of outpatients, but the attendance decreased to 41% in the evaluation of hospitalized patients. There was also low access to vascular surgeons, and they only attended the joint evaluation in just over 20% in both inpatient and hospitalized patients, regardless of playing an important role in the management of the diabetic foot by performing assessments of ischemia and evaluating needs for and types of revascularization [80]. Since ischemic complications are common in patients with diabetic foot disease, it is important to diagnose infection in order to immediately start adequate antibiotic treatment and evaluate the need for debridement. Additionally, according to the results of the Eurodiale study [16], more than half of diabetic ulcers become infected, which also indicates the need for the attendance of an infectious

disease specialist (preferable with competence in orthopaedic infections) in MDT care of the diabetic foot.

We did in our study notice a reduction in the attendance of all specialists in the joint MDT assessment of hospitalized patients compared to outpatients. These patients in their clinical situation should instead have maximal access to an optimal MDT. Essential skills for the care of hospitalized patients include the ability to stage a foot wound, to assess peripheral vascular disease, to treat neuropathy and wound infections, and the need for debridement [127]. Here we observe an area for improvement.

In many countries, the podiatrist plays a key role in MDT diabetic foot care [82,128–131] by managing foot ulcers through appropriate wound care, prevention of recurrence and also by applying proper offloading strategies [129,132]. Currently, there is no higher education program for becoming a podiatrist in Sweden.

6.4 TELEMEDICINE

Results from the two studies indicate a need for collaboration between hospitals with different resources and access to specialists. In paper I, 14 hospitals had joint orthopedics clinics, and 23 hospitals needed to referee the patients to another hospital for reconstructive surgery for foot deformities. In addition, paper II showed that some of the small and medium-sized hospitals in Sweden did not have access to a foot team, but referred the patients to hospitals with MDT competence. In order to be able to provide equal care for everyone, telemedicine could offer a solution by connecting small hospitals with specialists in larger hospitals in order to deliver health care and to share medical knowledge over distances. Patients with diabetic foot complications need frequent access to specialized care, and telemedicine could therefore also be a solution for primary care by reducing the need to visit the hospital and to promote equal care regardless of where the patient lives. The benefits of telemedicine not only consist of increased access to health services, but has also shown to be cost-effective, with improved health outcomes and quality of care leading to a better quality of life as well as enhanced educational opportunities for both health care providers and patients [133,134]. A report has shown that patients with chronic diseases such as diabetes want to be more active in their own care and to gain knowledge about the diagnosis and how to manage daily life [135].

Radiology services is one of the medical specialties that have embraced telemedicine technology in order to deliver optimal services in rural areas that are sparsely populated [136,137]. The need for delivering healthcare and sharing medical knowledge over a distance using telecommunication systems is not new: the first attempts were made in the early 1960s [138]. There was little advancement in the following decades, but in 1990 the development of capturing images and other data in digital electronic form made it possible for teleradiology to advance. Teleradiology could than start to solve medical needs to improve quality in a cost-effective way.

Telemedicine has been implemented to a limited extend in diabetes foot care delivery. A recent study of health care professionals´ experiences with telemedicine in diabetic foot care [139] indicated that increased contact between primary health care and specialist health care made communication between the two more efficient and saved time. A literature review from 2007 on the contribution of telemedicine confirms these findings [140]. Additionally, the review indicated that teleconsultation and videoconferencing could be cost-effective and reliable ways of providing diabetic care.

6.5 QUALITY MEASURES

The incidence of amputation has been suggested as a marker of quality of diabetic foot care [73]. Furthermore, in patients with diabetic foot disease, LEA, along with blindness, is most commonly reported as the most feared complication of DM [141]. However, the incidence of amputation is dependent on several factors that need to be taken into consideration when using amputation as a quality marker. The incidence is not only dependent on the severity of the disease, the quality of specialist care, professional opinion and the organization of local health services, but also on cultural and social issues [142]. Healed ulcers have also been used as quality markers of diabetic foot care; however, these measures alone do not provide any information on the health economy. Furthermore, they do not take into account vital aspects, such as functional ability and quality of life of the patients [126,143].

Studies from Norway and Denmark on the evaluation of diabetic foot ulcer teams also emphasize the need for quality improvement and adherents to guidelines [144,145]. In Norway, 17 out of 41 hospitals had diabetic foot ulcer teams, and only 9 foot teams had written routines for assessment [144]. Out of the 23 respondents in the Danish

evaluation, 42 % reported having an MDT in accordance with the national guidelines [145]. These results indicate the need for recurrent evaluation of MDT care of patients with DM and foot complications so as to find areas for improvement.

6.6 COMMENTS

A strength of the two studies was the positive attitude among the responding clinics to participate in the evaluations, which led to a high response rate. This might reflect how important they believe their work to be. The limitation of the studies is that we can only make an assumption based on the answers reported by the respondents. As in most questionnaire surveys, questions can often be interpreted in different ways.

Data were collected using structured questionnaires with response options provided, primarily, which obviously limits the opportunities for respondents to express themselves. In **paper I,** only conventional plain radiography, bone scintigraphy and MRI were given as response options concerning diagnostic imaging. However, other diagnostic methods are currently under evaluation but are not considered as clinical routines in Swedish hospitals.

A weakness of **paper I** is that the primary care physicians who might be the first health care contact of patients were not part of the inventory. Our findings indicate the need for further assessment of the caregiving of these patients also at the primary care level. However, we believe that as diabetes osteoarthropathy is an orthopedic issue, especially with respect to reconstructive surgery, it demands the highest and optimal mindset at the orthopedic clinic, in order to minimize the consequences of this rather rare but devastating complication. The knowledge of the orthopedic clinics should then actively and regularly be transferred to the primary care level. A limitation of **paper II** is that a pilot version of the questionnaire, developed in collaboration between DFCK and the Swedish Diabetic Association, was not created and evaluated before the final version was distributed.

As in most questionnaire surveys, questions can often be interpreted in different ways. Our study is no exception. In one of the questions, we ask which specialists the foot team has access to. These specialists do not have to be part of the team per se but can be

accessed via, e.g., referral or a phone call. Some respondents may have interpreted the question narrowly as an inquiry into which specialists were part of the foot team.

Furthermore, we asked which specialists attended the MDT evaluations of outpatient and hospitalized patients. The idea behind an MDT approach is that all specialists examine a foot at the same time in the same room, with each contributing different knowledge on the clinical situation, resulting in an improved care of the patient. In some cases, there seemed to be confusion about the actual meaning of the multidisciplinary approach concept.

When asking whether the hospitals had a *local* register of the annual number of amputations and healed ulcers, perhaps it should have been emphasized that the NDR (National Diabetes Register) is a central register and not a local register.

6.7 CONCLUSION

The inventory of diabetic osteoarthropathy care in Sweden clearly indicates a need for an improvement in knowledge at the national level as well as guidance and organization regarding the care of patients with osteoarthropathy. An international consensus discussion is also recommended in order to reach and maintain the optimal level of diagnosis and management of patients with suspected diabetes osteoarthropathy.

The MDT approach to patients with DM and foot complications has become established in Sweden, but there is a need for further improvement, especially for hospitalized patients and in small, local hospitals. Furthermore, the role of MDT needs to be clarified and extended in order to improve the quality of care.

Our study indicates that anational surveys can be a valuable tool in evaluating health care organizations and management in order to reach and maintain adequate and equivalent care for patients. This evaluation can also be used in identifying fields for further clinical research and bring opportunity for knowledge transfer.

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